IMPROVEMENT OF BOILING PROCESS IN FISH CRACKER PRODUCTION

MOHAMAD NAFIS BIN JAMALUDDIN

Report submitted in partial fulfilment of the requirements
for the award of the degree of
Bachelors of Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

JUNE 2013

ABSTRACT

Boiling process is performed at the final stage in fish cracker processing. Long process time of boiling create bottleneck that limits daily production of fish cracker. Traditionally, the heat is produce to boil water is by burning fire woods. The invention of diesel-fired boiler has improved the process but still there are some problem occurs at the station. Therefore, a new boiler is designed to improve the boiling process by using LPG burner which has 2.9 % higher calorific value than diesel. The boiler designed must be simulated to study the heat convection inside the boiler by using SolidWorks Flow Simulation to see the temperature distribution inside the new boiler. Multiple layers bottom plate of the boiler consist of an aluminium plate sandwiched between two stainless steel plates is used to increase the rate of heat transfer from the flame into the water inside the boiler. The result from the simulation proves that the multiple layers bottom plate of the boiler has a higher rate of heat transfer than the single layer plate where the time taken for water to boil is 42.2 % shorter than the single stainless steel layer bottom plate boiler.

ABSTRAK

Proses perebusan merupakan proses terakhir dalam pemprosesan keropok ikan. Masa yang lama diambil untuk merebus menyebabkan kesesakan yang menghadkan penghasilan keropok ikan seharian. Secara tradisionalnya, haba dihasilakan untuk merebus keropok diperolehi dari pembakaran kayu api. Penciptaan mesin perebusan yang menggunakan haba dari pembakaran diesel telah sedikit sebanyak membantu proses tersebut namun masih terdapat beberapa masalah yang timbul pada stesen tersebut. Oleh itu, sebuaah mesin perebusan direka untuk menambahbaik proses tersebut dengan menggunakan penunu LPG yang mana mempunyai 2.9% nilai kalori lebih tinggi berbanding diesel. Mesin perebussan tersebut dianalisi untuk mengenalpasti peredaran haba di dalam mesin tersebut dengan menggunakan perisian SolidWorks Flow Simulation. Mesin perebusan yang mempunyai lapisan aluminium diantara dua lapisan stainless steel digunakan pada permukaan bawah mesin tersebut untuk meningkatkan kadar pindahan haba dari api ke dalam air di dalam mesin perebusan. Keputusan simulasi meunjukkan mesin perebusan dengan permukaan bawah pelbagai lapisan mempunyai kadar pindahan haba yang lebih tinggi berbanding permukaan bawah satu lapisan dimana masa yang diambil untuk mendidhkan air adalah 42.2 % lebih singkat berbanding mesin perebusan yang mempunyai satu lapisan stainless steel.

TABLE OF CONTENTS

CHAPTER 3 RESEARCH METHODOLOGY

CHAPTER 4 RESULTS AND DISCUSSION

CHAPTER 5 CONCLUSION AND RECOMMENDATION

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Q	Rate of heat transfer
T_{∞}	Surface temperature
k	Thermal conductivity
h	Convection heat transfer coefficient
R_t	Total thermal resistance
R_{conv}	Convection resistance
R_{eq}	Equivalent thermal resistance

LIST OF ABBREVIATIONS

SMI	Small and Medium Industry
ECER	Surface temperature
CFD	Thermal conductivity
CAD	Convection heat transfer coefficient
3D	Total thermal resistance
SSt	Convection resistance
Al	Equivalent thermal resistance
LPG	Liquefied Petroleum Gas
CPU	Computer Processing Unit
DAQ	Data Acquisition

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter explains about overview of fish cracker industry, East Coast Economics Region (ECER), the problem statement, objectives and the scopes of the project. Fish cracker is one of the famous and highly relished snack foods in Malaysia and it is originated from east coast of peninsular Malaysia (Omar et al., 2001). It is well known and highly demanded due to its crispy on the outside but tender on the inside if it is fried. Besides, fish cracker can be eat by just boil it which gives fishier flavour according to some people. Both fried and boiled fish cracker is best to be eaten with special fish cracker chilli sauce. The main ingredient of fish cracker is fish, sago flour, salt and water. The high requirement of fish cracker in the market urge entrepreneurs to increase their production but they face a lot of problem to fulfil the market demand. In the production of fish cracker, most manufacturers are still using traditional manufacturing practices with low competitiveness and poor efficiency which limit the daily production of the fish cracker. As a result, these manufacturers cannot meet the demand of the customer. Salomonsson (1984) claimed that the development of local food and regional food are crucial for the industry. Thus, there is a necessity to employ a standard processing procedure in order to keep the quality while meeting the high production to provide the consumer demands of the delicious fish cracker. There are several stages of processing that are needed to be taken to make fish cracker as shown in Figure 1.1.

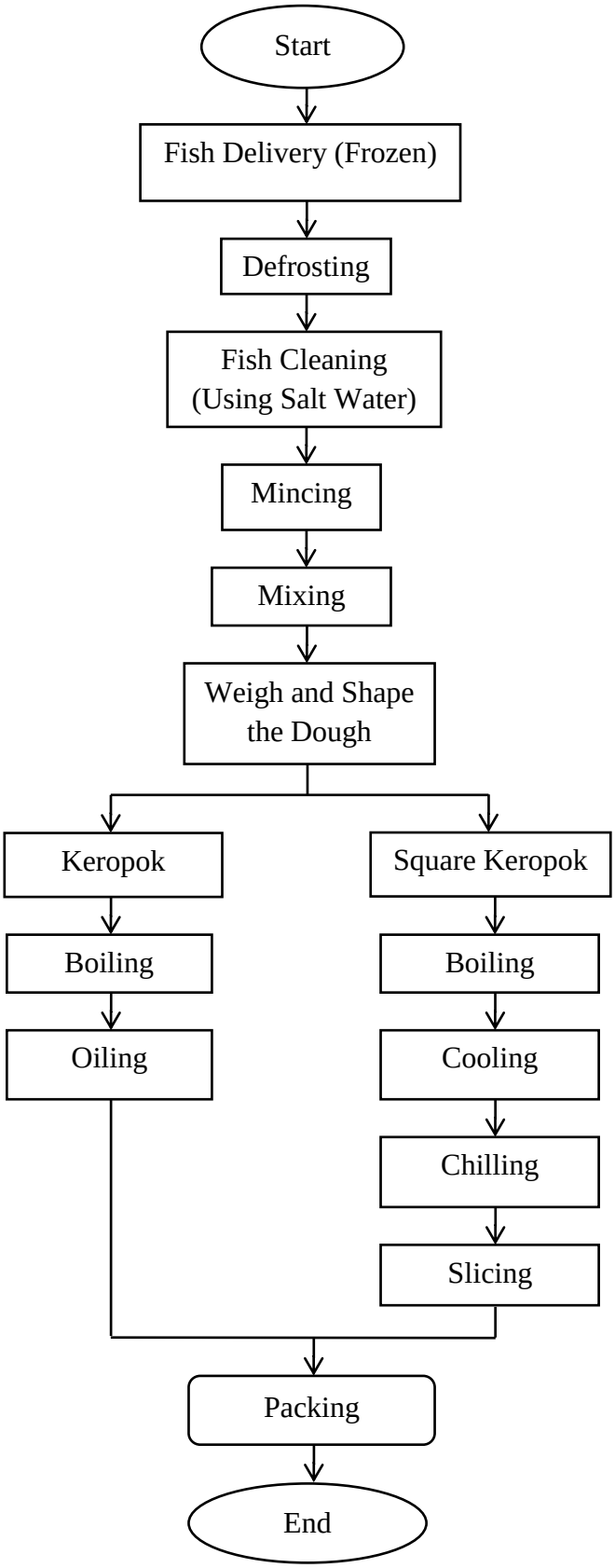

Figure 1.1: Process sequence in fish cracker manufacturing

Previously, fish cracker manufacturers carry out the processes manually such as the process to roll the dough into huge sausage-like fish cracker and shaping square fish cracker is still being done manually. In addition, the process to boil the fish cracker is done traditionally by boiling water from burning firewood. This method is not very efficient where it is difficult to control the fire and it also produces smoke and soot to the surroundings. Therefore, at that moment, the manufacturers cannot produce high production of fish cracker to meet the market demand.

Figure 1.2: Wood-fired fish cracker boiler

Source: Department of Tourism Terengganu

Nowadays, Small and Medium Industry (SMI) sector has improved very well in the term of their manufacturing method. The technology that is used in other food processing industry such as nugget, burger and meat ball has influenced many local foods including fish cracker to be commercialized (Tukiran, 2009). The fish cracker manufacturers have improve their processes hence increase the production of fish cracker by the use of automated machines to perform a certain task such as the processes to mince and mixing the kneaded fish meat. Other than that, automatic diesel fire-tube burner is installed to the boiler to perform the task boiling of fish cracker. Automated processes can help fish cracker manufacturers to increase the production to meet the market demand.

1.2 EAST COAST ECONOMIC REGION

Fish cracker industry has caught the eye of the Malaysian government therefore it is included into East Coast Economic Region (ECER) as the east coast of peninsular Malaysia is rich in resources and the raw material for fish product food. The fish industry is put under food and halal product initiatives. Table 1.1 shows the location and the focused project for the fish processing industry.

Table 1.1: Fish processing industry

Location	Project Focus
Bachok	Fish processing
Tok Bali	Integrated fisheries park
Chendering	Food processing (fish & poultry based)
Kuala Kemaman	Food processing (fish based)
Tanjung Api	Fish Processing

Source: ECER (2004)

1.3 PROBLEM STATEMENT

Traditionally, the process of boiling fish cracker is by burning firewood. This method is not suitable as it is hard to control the fire, efficiency is low where a lot of firewood is used and the burning of firewood produces smoke and soot on the surrounding. Currently, the invention of fire tube burner by using diesel fuel has improved the boiling process. This burner does not need a worker to control the fire as the diesel injection is automatically control via temperature sensor that sense the temperature of the water inside the tank. Furthermore, the smoke from burning diesel is channelled away from the working area. This is a lot better than the previous one as the water boils faster by using this method.

Apart from that, the burner still has few things to be improved because the uneven temperature distribution as the temperature of water near the diesel burner is high but it decrease as it moves far from the burner. The result of this problem is the

fish cracker that are put on the side near the burner cook faster than the fish cracker that are placed further from the burner which lead to the bottleneck on the production.

1.4 OBJECTIVES OF THE PROJECT

The objectives of this study are:

i) To identify the bottleneck in fish cracker process plant.
ii) To design new boiler for fish cracker processing.
iii) To simulate heat convection inside the new boiler by using Solidworks Flow Simulation.

1.5 SCOPES OF PROJECT

In order to achieve the objectives listed, the scopes of this study are as defined below:

i) Feasibility study on different heating configuration using fuel and electric.
ii) Design new heating system and boiler for uniform water boiling in large tank.
iii) Simulation study for the proposed tank.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter explains about the current research in fish cracker industry, application of computer numerical in production planning, bottleneck in fish cracker processing and the boiling process of fish cracker, heating configuration of the boiler, the design of the boiler and simulation analysis of heat distribution of the boiler.

2.2 FISH CRACKER INDUSTRY

Malaysia is unique country of different cultures that has led to in varieties of foods. It is important that these traditional foods are preserved for future generations. By using modern technologies and traditional techniques, manufacturers could produce more hygienic way of processing and preserving food (de Roest and Menghi, 2000). Thus, there is an urgent need to refine the processing of traditional foods in response to new societal needs. Refining and sustaining traditional foods are essential in facing the forces of globalization (Trichopoulou et al., 2007)

In the production of fish cracker, most producers are still using traditional manufacturing practices with low competitiveness and poor efficiency. Therefore, there is a need to employ a standard processing procedure in order to maintain the quality while meeting consumer demands for safety, quality and nutritional value of these foods. Traditionally, fish cracker is precooked by boiling in water. Study by Bakar (1983) reviewed the boiling and steaming methods in processing fish cracker. The researcher found that steaming of fish cracker does not prove to be feasible and the

study suggested several modifications in the processing steps in fish cracker preparation are essential. On the other hand, Omar et al. (2008) reviewed in terms of sustaining and promoting of this local food, more publicity should be performed continuously and producers of fish cracker must achieve consistent quality and safety as it represents Malaysia's identity. Traditional fish cracker production methods result in products of poor quality, with uneven expansion characteristics, dark objectionable colours and varying shapes, sizes and thicknesses as well as low hygiene (Yu et al., 1981). Siaw and Idrus (1979) have attempted to upgrade product quality. They have introduced mechanization and standardization into fish cracker making. Their process is less time consuming and gives a better-quality product compared to the traditionally produced fish cracker. The two essential ingredients in fish cracker making are starch and fish. Fish such as 'Ikan Parang' (Chirocentrus dorab), 'Ikan Tamban beluru' (Clupea leiogaster) and 'Ikan Selayang' (Decapterus macrosoma) are preferred although other fishes are also used for making fish cracker. Tapioca or sago starch is used but sago starch is said to give the best product in terms of texture and flavour (Taewee, 2011). Fish cracker can be eaten as soon as it is boiled and together with chili sauce.

2.3 BOTTLENECK IN FISH CRACKER PROCESSING

The purpose of boiling fish cracker is to precook for further processing although it is palatable with chili sauce for some people. According to Bakar (1983), only 15 minutes of boiling required to achieve complete cooking of fish cracker while 3 hours is needed to achieve the same result by steaming. Processing conditions such as boiling of product can reduce microbial levels, although recontamination takes place during post-processing and handling of food (Sachindra et al., 2005).

2.4 BOILER SPECIFICATIONS

There are several factors that must be studied before designing a boiler such as material, heating configuration, temperature distribution and heat transfer rate (Pohekar et al, 2004). Designing a boiler without a proper research on the topic will lead to a failure and will waste lots of money if the design is fabricated. Therefore, appropriate study on the boiler specifications should be done before designing it to ensure the new

boiler will produce good heating characteristics and improved the production in the boiling station in fish cracker processing.

2.4.1 Temperature Distribution

Temperature distribution plays an important role for a boiler in the boiling station as it will affect the cooking time for the fish cracker (Khaizura et al., 2009). Uneven temperature distribution will lead to bottleneck where 10 to 15 minutes are taken to check whether all fish cracker are properly cooked. Therefore, the shape and the geometry of the boiler must be able to allow even temperature distribution inside the boiler. It is very crucial for the boiler to have the characteristic because it will solve the problem of different cooking time of the fish cracker.

2.4.2 Material Selection

Another important factor in boiler specifications is material selection for the boiler. Different material has their own characteristics such as mechanical properties, thermal properties, corrosion resistance and durability. Important aspect such as hygiene is vital in fish cracker processing as poor hygiene may lead to health illness such as food poisoning to the consumers. The contamination of surfaces by spoilage and pathogenic micro-organisms is a cause of concern in the food industry. One of the decisive arguments when choosing materials for processing line equipment, along with their mechanical and anticorrosive properties, has become hygienic status (low soiling level and high cleanability). Of these materials, stainless steel, which is widely used for constructing food process equipment, has previously been demonstrated to be highly hygienic (Holah and Thorpe, 1990). However, stainless steel can be produced in various grades and finishes, affecting bacterial adhesion because of their various topographies and physic-chemical properties (Fontaine et al., 1990). The main difference between commercially available grades is their relative composition in iron, chromium and nickel. Austenitic stainless steels containing chromium and nickel, such as AISI 304, are widely used in the food industry because of their high resistance to corrosion by food products and detergents.

Other elements may be added to improve anticorrosive properties, such as molybdenum in AISI 316, often used in dairies. Other materials such as ferritic stainless steel are used in various applications because of how easily they can be formed and welded (catering). Moreover, one grade can be obtained in more or less rough finishes such as pickling finish (2B) and bright annealed (2R), depending on their final steel making process (Petermann, 1996). Higher heat conductivity of the cooper used as heating plate can result in short recovery time (Rodgers, 2006).

2.4.3 Heating Configuration

Traditionally, the process of boiling fish cracker is by burning firewood. This method is not suitable as it is hard to control the fire, produces smoke and soot on the surrounding. Plus, open fire cooking by using woods can results in incomplete combustion and indoor air pollution which might lead to respiratory and other diseases to the workers who are exposed and afflicted through working hours near the fire (Bruce et al., 2000; Padmavati and Pathak, 1959). Further, the smoke from the wood burning is a source of greenhouse gas emissions (Ludwig et al., 2003). Currently, the invention of fire tube burner by using diesel fuel has improved the boiling process. This burner does not need a worker to control the fire as the diesel injection is automatically control via temperature sensor that sense the temperature of the water inside the tank. Apart from that, the burner still has few things to be improved because the uneven temperature distribution. The result of this problem is the fish cracker that are put on the side near the burner cook faster than the fish cracker that are placed further from the burner which lead to the bottleneck on the production. In addition to the burner, it also has a blower to circulate the heat along with vents that remove the by-products of combustion and allow fresh air to flow into the burner for a steady burn rate. One of the most important aspects in making a good heating system is the design of the heating system and its tank. Therefore, factors such as better temperature distribution and control, faster cooking, less energy, safer operation, better sanitation and flexibility must be taken into account in considering the design. Plus, the shape of the heating unit is also an important design consideration. Ekundayo (1994) stated that the optimum configuration to achieve the most steady-state rate of convection was with the heating element placed in the lower half of the tank.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter discusses about all the methods that are used for this research. This chapter is divided into two parts which will define the analysis of the heat convection inside the boiler. The methods used in this project are experimental and simulation. The simulation method is performed to study the heat convection inside the new boiler by using the finite volume analysis.

3.2 FLOW OF THE PROJECT

A new boiler is design in order to solve the problem in the boiling station in fish cracker processing. The modelling of the new design is completed by using SolidWorks software. The simulation of the heat convection inside the new boiler is performed by using finite volume analysis. An experimental test method is performed in order to examine if a correlation between the test method and the simulations exist. The parameter used such as flame temperature, volume of water, thermal conductivity of the material and the geometry of the boiling pot are same for both experiment and simulation. The research proceeds to simulate the heat convection inside the new boiler by using the equal simulation technique. The terminology of work and planning for this research was shown in the flow chart Figure 3.1.

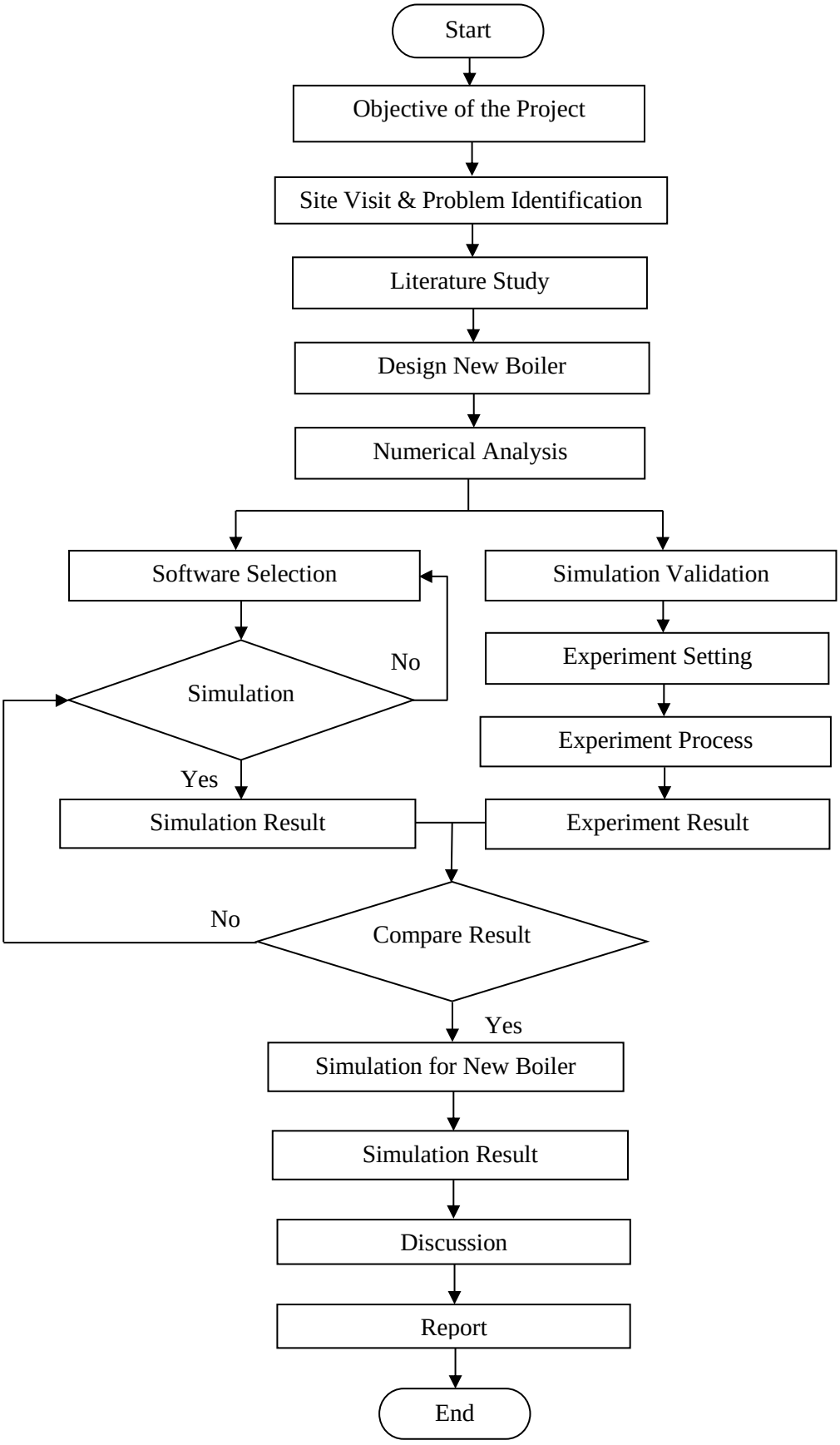

Figure 3.1: Flow chart of the project

3.3 DATA COLLECTION

Site visits to one of the factory that produce fish cracker is held in order to get the sufficient information and data. The factory is Kilang Keropok Mak Teh which is located at Tanjung Lumpur, Kuantan. The fish cracker factory is already running for 33 years. For the research purpose, the data collections were based from the observations on the plant and the processes, and interview with owner and workers which are done during the site visit. Then the data collected will be analysed and become the consideration for designing of the new keropok boiler. Figure 3.2 shows the production in the factory.

Figure 3.2: Production in the factory

3.3.1 Temperature Distribution

Based on the observations during the visit to the fish cracker factory, the boiler that is used to cook fish cracker is a diesel-fired boiler. A motor-driven blower is used to blow the mixture of diesel and air and the fire flows through a tube inside the water tank to heat the water. Figure 3.3 shows the blower that is used on the boiler.

Figure 3.3: Diesel-fired blower

The fire from the blower flows through a U-shape tube inside the tank. From the observations, the water boils faster on the side near the blower and vice versa on the side further from the blower which is shown in Figure 3.4.

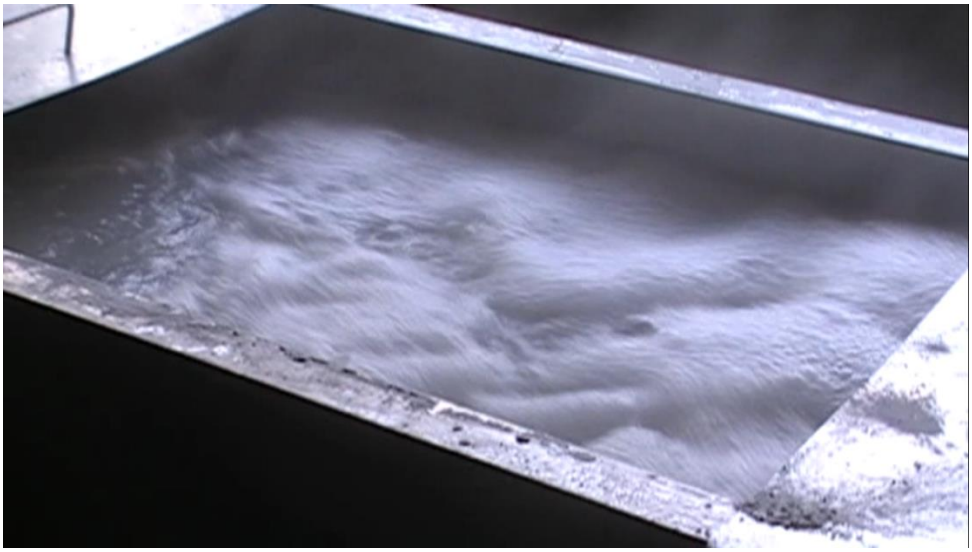

Figure 3.4: Heat distribution inside the tank

Figure 3.5 shows the drawing of the tank that is used to boil fish cracker at the factory. The fire from diesel burning flows inside the hollow tube inside the tank which heat is transferred to the water. To prove that the temperatures are varies inside the